APPENDIX A

Walt Roehr, TNC 703-435-1787 November 13, 1996

Fixed Service Point-to-Point Hubs

Warning: The following text is a limited discussion of the spectrum usage characteristics of a short-range, high-density, hub-based deployment. A more thorough analysis is underway. The following text does not address ad hoc link deployments. It also does not discuss the fact that high-density, long-range applications (i.e., roughly 4-8 km) are present in the current and foreseen FS networks and deployments.

Each carrier currently providing service in the 38.6-40 GHz band is evolving its own deployment plan and it can be expected that future entrants into this band will develop their unique plans. However, the nominal plans of WinStar Communications, Inc. (perhaps the leading, or at least the largest, carrier in this band) can provide insight into the electromagnetic environment that can be expected in much of this band.

In order to circumvent logistics problems inherent in ad hoc link installations, WinStar has developed a hub deployment scheme. A given hub has unique responsibility for a portion of the service area. At this time all of the links at a hub are operated on a point-to-point basis but it can to expected that (with the evolution of the capabilities of the radios, the needs of the users, and the FCC radio regulations) point-to-multipoint radios (possibly using fan beams) will be deployed. A number of the links at a hub will have elevation/depression angles of 45 or more degrees, thus facilitating interconnection of tall buildings (typically hubs) and short buildings. An advantage of these "slant links" is the additional frequency reuse they allow—"sectors" can be separated in elevation as well as azimuth.

In a clear air situation frequencies can be re-used every 3 to 4 degrees around a hub. If rain-induced fading of the desired and interfering stations is uncorrelated a fade margin must be added, however, it is expected that the relatively short path lengths that come with a dense deployment of hubs will result in a fairly high degree of correlation and the ability to offer high availability links with frequency reuse separations of 20 degrees—other frequencies would be used between these re-uses.

When we consider inserting Fixed Satellite Service ground stations in this scenario there are significant impacts. Note that, depending upon the channelization of 90 MHz satellite transponders, it is likely that three 50 MHz terrestrial channels will be blocked by one satellite channel (and the three channels paired with these channels will be rendered useless). Also note that shifting around frequency assignments to avoid a satellite ground station involves more than just the link—the entire frequency assignment plan for the hub (and possibly all adjacent hubs) is affected. Further note that re-orientation of the link is typically not possible—the hub locations are pre-selected to provide area coverage—blocking particular link orientations from a given hub results in non-recoverable holes in the coverage pattern. As hub-based high-density 39 GHz service evolves from point-to-point pencil beams to point-to-multipoint fan beams (assuming this natural evolution is blessed with regulatory approval) the situation becomes more critical.

Hexagonal service areas are a standard analytical assumption that is valid for a flat earth. While the actual service areas will be determined by the local terrain, the hexagonal assumption provides a good model for average capacity calculations.

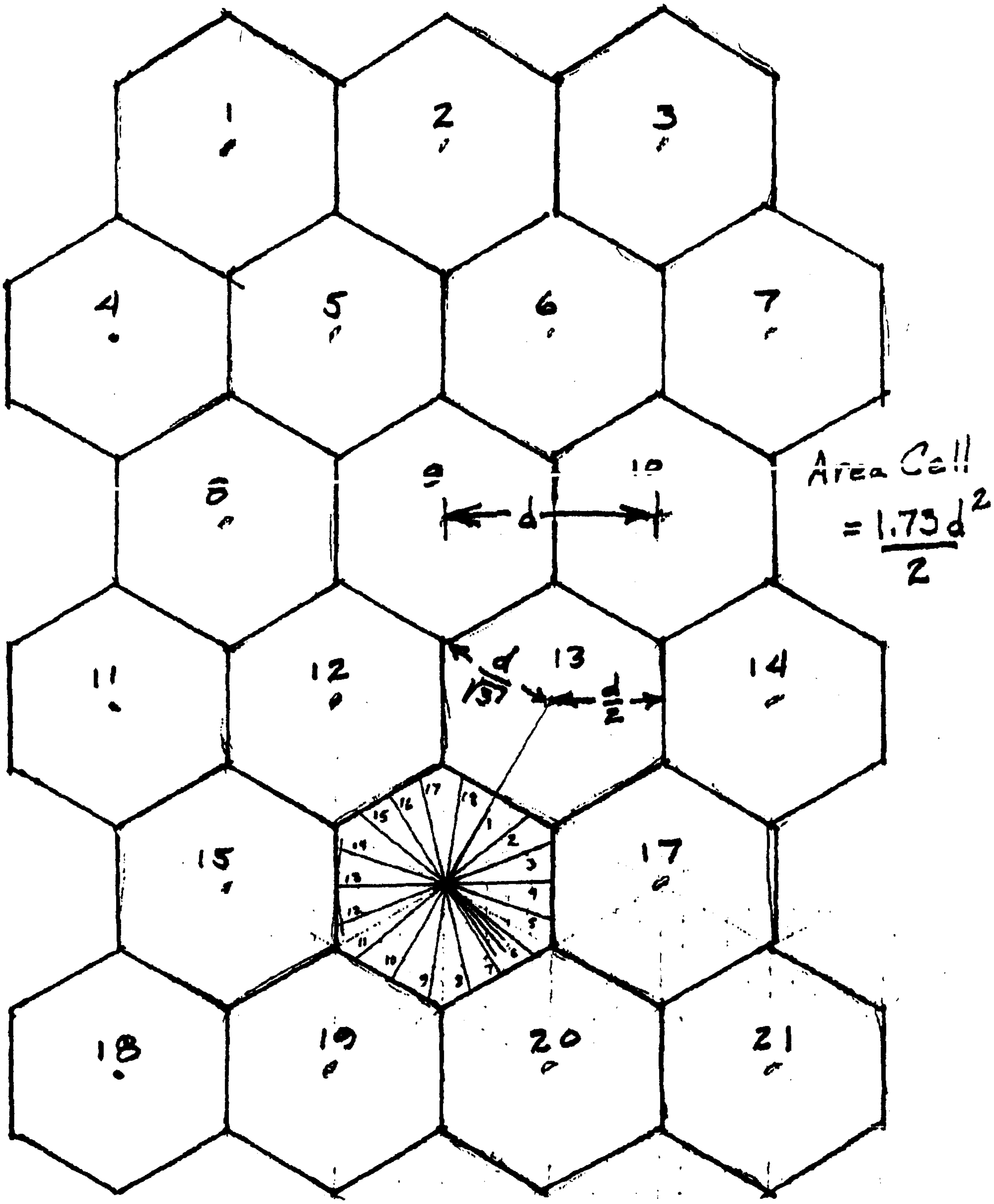

Figure 1: A Typical Metropolitan Area Short-range, High-density, Hub-based Deployment

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APPENDIX B

Contribution To The Ad Hoc Millimeter Wave Advisory Group Of The WRC-97 FCC Industry Advisory Committee

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Document Ad Hoc MW/48
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References: Document No. Ad Hoc MW/7-Rev. 4
Document No. Ad Hoc MW/36
Document No. Ad Hoc MW/37
Document No. Ad Hoc MW/40-Rev. 1

Doc. Ad Hoc MW

Feasibility of Co-Frequency Sharing between the Fixed Service and the Fixed Satellite Service in the 37 - 40.5 GHz and 47.2-50.2 GHz Bands

1. Introduction

This paper responds to Ad Hoc MW Document No. 40 and Ad Hoc MW Document No. 40-Rev. 1 (Jointly "Ad Hoc MW/40R1") submission by Motorola Satellite Communications, Inc. ("Motorola") concerning issues impacting the compatibility of its proposed "M-STAR" fixed satellite service ("FSS") system with existing and planned fixed service ("FS") systems. We have reviewed Ad Hoc MW/40R1 and believe that the approach proposed therein is incompatible with existing Fixed Service ("FS") operations and would prevent FS licensees from meeting their customers' flexible deployment, availability, and path length requirements. The Ad Hoc MW/40R1 proposal also would thwart the ability of FS systems to employ more advanced and cost efficient equipment in the future. Consequently, band segmentation is the only viable solution. The main issues of concern are addressed below.

2. Background

The existing international shared co-primary FS/FSS allocations in bands above 30 GHz were established at WARC-79 without contemplating the type of FS/FSS sharing proposed in Ad Hoc MW/40R1. The issue of compatibility between FS and FSS systems in bands above 30 GHz lay essentially dormant for many years. Recent developments in millimeter wave transmission technology made commercial operations in the subject frequency bands feasible for the first time just a few years ago. Rapid FS deployment ensued thereafter.

Thirty-seven/thirty-nine GHz FS implementation was much more advanced than were the FS implementations at other high frequency bands (e.g., 28 GHz) when faced with co-primary satellite/terrestrial sharing matters. As noted in recent press accounts, expansion continues daily in the 38 GHz band by terrestrial service providers.[1]

The situation envisaged at WARC-79 for sharing between FSS and FS services has proven to be inappropriate in today's environment. The ubiquitous nature of modern FSS systems, particularly those proposed in the higher frequency bands, is incompatible with current sophisticated terrestrial digital FS systems, which exhibit equal if not greater deployment densities as compared to their FSS counterparts.

Ad Hoc MW/40R1 proposed that FS systems in the 37/40 GHz band be required to:

(i) operate under a highly restrictive clear air peak FS EIRP limit of -28.4 dBW/MHz;

(ii) utilize automatic (or adaptive) transmit power control ("ATPC") to "allow" FS systems to only exceed the proposed peak clear air EIRP limit under adverse propagation conditions; or

(iii) undergo traditional frequency coordination with FSS operations.

Based on the resulting assumed FS parameters, Ad Hoc MW/40R1 concludes that FS systems could operate at a minimum separation distance of 1 km in the 37/40 GHz band without causing harmful interference to an FSS earth station receiver. Ad Hoc MW/40R1 also stated that "[h]igher power terminals need to be coordinated."

In the case of sharing between FS and FSS Earth-to-space operations in the 47/50 GHz band, Ad Hoc MW/40R1 indicated that separation distances on the order of about 70 km would be necessary to protect FS receivers from harmful interference caused by FSS earth station emissions, and that coordination would be required. Ad Hoc MW/40R1 also proposed a peak FS EIRP density limit as a function of elevation angle in order to protect FSS space station receivers from the emissions of FS stations. These conditions would virtually eliminate the possibility of operationally viable FS and FSS operations in a shared co-primary environment imposing severe geographic impediments to both services. As shown below, the Ad Hoc MW/40R1 proposals do not provide a workable solution to the problem of FS/FSS sharing in bands above 30 GHz.

3. Analysis of FS interference into M-Star Earth Stations

FS operations would cause harmful interference into M-STAR earth stations. Ad Hoc MW/40R1 presented the results of I/N calculation that specified a proposed maximum terrestrial FS EIRP with power control in place that would purportedly allow compatible Fixed Service and

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[1] Recent publicly announced 38 GHz FS Service contracts are for thousands of links.

M-Star earth station operation at a minimum distance separation of 1 km. It also was stated that FS terminals that exceeded this EIRP would not be compatible and would need to be coordinated. The interference analysis and subsequent power control restriction was based on protecting an earth station receiver using an I_O/N_O criteria of -13 dB. The determination of the EIRP density limit was based on the maximum I_O/N_O that the earth station receiver could tolerate at a distance separation of 1 km. The determination of the EIRP density was based upon characteristics and requirements of a hypothetical power-limited FS system conceived by Motorola. ATPC was proposed as a means to facilitate the EIRP density limit on the part of the FS operators, but did not take into account the physical realities of the application of the ATPC or the characteristics of the FS transmitters. The amount of power control necessary to achieve the EIRP limit exceeds the total amount of FS signal margin available for all purposes, and it far exceeds the capabilities of ATPC technologies available to FS manufacturers on a cost-effective basis. Advanced FS systems are presently being designed that will permit higher transport capacities and utilize a transmit EIRP of at least 40 dBW, and allow for a more efficient use of the radio spectrum. EIRP on the order of 50 dBW has been specified for longer-term advanced systems.[2]

In this paper the actual I_O/N_O that is likely to be present at an earth station receiver is calculated, and this value is compared with the I_O/N_O criteria to determine the amount of power control necessary for compatible operation at a distance separation of 1 km. The actual I_O/N_O was then compared to the link margin available to an FS link to determine if the power control necessary to ensure the I_O/N_O of -13 dB is possible to achieve under real-world conditions.

The actual I_O/N_O at the M-Star earth station receiver was calculated based on the FS transmitter EIRP in the direction of the earth station receiver, the earth station receiver noise level (N_O) and off-axis antenna gain in the direction of the FS transmitter, and propagation path loss corresponding to a path separation of 1 km. The resulting I_O/N_O was then compared to the threshold I_O/N_O of -13 dB. Equation 1 was used to calculate the I_O/N_O .

$$Io/N_O = P_T + G_T + D_{PFD} - L_P + G_R - N_O \qquad (1),$$

where:

P_T =	FS transmitter power, (-13.01 dBW in 5 MHz bandwidth)
G_T =	FS transmitter antenna gain in direction of earth station receiver, 44 dBi
D_{PFD} =	Power flux density correction factor (10 Log 1 Hz/5 MHz), -67 dB
L_P =	Wave spreading and atmospheric absorption loss for a 1 km path, 124.6 dB
N_O =	Earth station receiver noise level, -201.58 dBW/Hz
G_R =	Earth station receiver antenna gain in direction of FS transmitter, -1.56 dBi

The assumed FS transmitter corresponds to a currently operating DS-1 data rate system. The FS transmitter antenna was assumed to be pointing in the direction of the earth station receiver with a 0 degree elevation angle and an EIRP of 31 dBW. The earth station receiver

2 See ITU-R Recommendation F.758.

antenna was assumed to be pointed 22° above the horizon resulting in a G_R of -1.56 dBi. The earth station receiver noise level, threshold I_0/N_0, and off-axis antenna gain were provided by Ad Hoc MW/40R1. The free space wave spreading loss for a 1 km path is 124.48 dB, and the corresponding atmospheric absorption is 0.13 dB for a total L_P of 124.61 dB.

The resulting I_0/N_0 was computed to be 39.41 dB using Equation 1 and the input parameters listed. This result is 52.41 dB in excess of the desired threshold I_0/N_0 of -13 dB.

The I_0/N_0 calculation reflects the current EIRP capabilities of a Fixed Service transmitter. This system is 24 dB below the 55 dBW international FS EIRP limit for the 37/40 GHz band. As mentioned before, the advanced FS systems that are planned for near-term future deployment will employ higher powered transmitters, and correspondingly higher EIRP of at least 40 dBW. In addition, for this exercise the FS transmitter antenna was assumed to be pointed at the horizon, allowing a 22° off-axis angle to be used for an earth station antenna. In reality, some number of FS antennas point at angles of up to +/- 60° with respect to the horizon. This has the effect of increasing the effective earth station antenna gain in the direction of an FS transmitter from -1.56 dBi to a higher value for certain path geometries. Both the increased FS EIRP and earth station off-axis antenna gain effectively increases the I_0/N_0 experienced by an earth station receiver.

The use of ATPC by FS is not a viable solution:

- The design of current equipment does not easily lend itself to ATPC applications, and the power range proposed by Motorola does not seem to be realistically achievable in the future.
- Protecting FS systems using ATPC against interference degradation is a problem which has not been addressed.
- It is doubtful that ATPC can be of real value at these frequencies due to the frequent non-correlated rain events between stations.

However, despite the fact that ATPC is not a viable element of an FS/FSS sharing solution, for the sake of discussion, this paper addresses the technical points raised by a hypothetical implementation of ATPC.

The amount of hypothetical FS power control required to allow a 1 km separation between M-Star earth stations and FS systems will exceed the total margin available (49.7 dB) for a typical 2.3 km FS link by 2.7 dB. If the whole FS link margin was actually available for power control -- which it is not -- the minimum distance separation would be approximately 1.4 km instead of 1 km.

The above-stated FS link margin is necessary to protect the required 99.999% threshold system availability from rain attenuation, as well as from multipath and other fading effects for path length parameters that are required for viable commercial operation based on actual deployment experience. The total FS link margin is required to protect from the worst case situation caused by rain attenuation. However, under non-rain conditions, a portion of the total margin is still required to protect from interference and other fading effects. Consequently, the total margin cannot be utilized for ATPC.

If ATPC is used to minimize FS interfering power into earth station receivers, then FS receivers become more vulnerable to interference from FSS downlink transmissions. The use of ATPC would operate to remove the margin that protects FS receivers from interference from downlink emissions except in the case of mainbeam coupled events during rain. Assuming ATPC is implementable, interference to FS receivers from FSS downlink signals would occur whenever a satellite was in the mainbeam of an FS receiver, not just under rain conditions. The current link margin available to FS receivers could protect them from downlink interference in all but stringent mainbeam rain attenuated cases. The use of ATPC would remove that protection, rendering FS systems more susceptible to harmful interference from FSS downlink operations.

Assuming that it would be technologically feasible and economically rational to implement FS ATPC for purposes of facilitating compatibility with shared FSS operations, the added capability would still not approach the necessary ATPC levels that can be assumed using the calculations set forth in Ad Hoc MW/40R1. If FS power control could be implemented, the amount of power reduction would depend on a trade-off between the allowable interference to FS receivers from downlink emissions, and the minimum acceptable distance separation between FS transmitters and earth stations for compatible operation. Currently if all of the FS margin is used for power control -- which it, as a practical matter, cannot be -- the minimum distance separation is 1.4 km (6.2 km^2 area) and FS receivers will receive interference from downlink signals whenever a satellite is in the mainbeam of an FS receiver. Hypothetically, if 10-15 dB of ATPC were applied[3] in a shared FS/FSS environment, a separation distance over the radio horizon would be necessary. Under these circumstances, the lost service area for both services that would result from co-primary FS/FSS operations would be unacceptable given the high-density deployment requirements in both services.

Motorola's conclusion that sharing is possible is premised upon the use of power control and the EIRP density limits. That premise is fundamentally incorrect, particularly in view of the fact that ATPC is not considered viable in these frequencies. Much of Motorola's thought about the effectiveness of power control seems to have revolved around the situation when the FSS station is located either on or close to the line between the interfering FS transmitter and the FS receiver. In this situation, the correlation of the rain-induced path attenuation on the FSS downlink path and the various portions of the FS path will necessarily be higher than for the cases when the FS link path diverges widely from the direction to the FSS station. In such cases, obviously the correlation of the rainfall intensity between the paths will be lower, perhaps considerably lower. Thus, the use of ATPC for the FS sidelobe coupling cases causing interference to M-Star downlink stations will not be sufficiently effective in mitigating

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3 See generally, Interference Criteria for Microwave Systems, TIA/EIA Telecommunications Systems Bulletin, TSB10-F (June 1994) at 4-10, 4-11. Manufacturers indicate that a maximum of 10-15 dB of automatic power control is the uppermost limit on today's FS equipment. Further, ATPC is not normally an option available above 15 GHz.

interference. For FS systems to expand and fully utilize the power and bandwidth available, as well as the full extent of the area license, the adoption of the EIRP density level proposed is not reasonable or viable. Any EIRP density limit would present unreasonable constraints. For example, in early market penetration, long range capabilities are required to connect distant users. These links rapidly evolve to form higher density networks. In late market penetration, long range capabilities are still required to connect fringe areas with high density networks. The use of power control and EIRP density limits would fail to address feasible equipment redesign, remote telemetry, power supply and equipment production factors.

4. Adverse Impact on the FS of the -28.4 dBW/MHz EIRP Density Limit

Motorola's proposed -28.4 dBW/MHZ EIRP density limit would effectively eviscerate current FS operations. Under normal circumstances there should be a minimum margin above the threshold[4] in order to account for various transmission perturbations while still providing the required nominal channel performance. Using a 1 ft diameter receive antenna, and assuming the proposed EIRP density limit, the following margins were determined for the systems shown below. These are not acceptable for normal applications.

(i) An off-set OQPSK system results in approximately 7.5 dB margin at 1 km for many locations in the U.S. For example, in New Orleans, to meet the required availability of 99.999%, the distance would be limited to around 0.5 km.

(ii) Assuming only free space propagation losses on the FS link, insufficient signal level is received for an advanced 256-QAM system even for a path length of only 0.5 km. In fact, the margin is used up after only 0.25 km distance. A 16-QAM system only has a margin for normal operation of 0.7 dB at a path length of 1 km.

Even though Ad Hoc MW/40R1 indicates that Motorola is prepared to accept interference at the EIRP density level of -28.4 dBW/MHz, because FS stations are very likely to be closely located to FSS earth stations for business reasons, the significant interference environment would present an untenable situation in many cases.

5. Downlink Interference In The FS Service

Motorola presents inconsistent PFD and EIRP levels throughout its application. Irrespective of which EIRP or PFD levels are used, the resultant interference is unacceptable to the FS system. Assuming that the M-Star signal level at the 25° elevation angle is at the PFD limit of -105dBW/m^2/MHz for an FS station with Ts = 1000 K and a gain of 44 dBi for the receiving antenna (2 ft diameter). The interference power I_0=-105-10 log (10^6)Hz - 53.5 +44 = -174.5 dBW/Hz

[4] The margin might be well over the 6 dB proposed in Ad Hoc MW/40R1 for satisfactory performance. The C/I ratios are known to degrade in the proximity of the threshold. There is very little test data available to correctly assess the minimum acceptable margin.

$$N_O = -204 dBW/Hz + \log(1000/290) = -198.6 dBW/Hz$$

Thus the I_O/N_O at the FS receiver is equal to -174.5 -(-198.6) or 24.1 dB, an amount that is 37.2 dB above the acceptable level of I_O/N_O=-13dB. If a receive antenna of 1 ft in diameter was considered (G=39dBi) the excess amount would be 32.2 dB.

From Motorola's application at Appendix A we note transmit clear sky EIRP levels of 22.1 dBW (10.24 Mbps) and 33.9 dBW (51.84 Mbps) which we calculate to represent PFD levels of -127.3 and -122.5 dBW/m^2/MHz. Use of these levels would still represent excess interference of between 15 and 20 dB above the I_O/N_O = -13 dB. Similar results are arrived at when using the carrier parameters in the M-Star Application at Appendix C.

Using the PFD limit and assuming the receive antennas meet Section 101.115 (c) of the Federal Communication Commission's Rules for Category A antennas for frequencies above 31 GHz, the specified minimum antenna discrimination levels versus angle from antenna boresight, are provided in Table 1. Also provided in Table 1 are the I_O/N_O ratios, and the amount these ratios exceed the acceptable level of -13 dB, that result from M-Star downlink interference into an FS receiving system as a function of the angular amount the boresight of the FS antenna is away from the boresight of the M-Star downlink antenna spot beam.

Table 1. Minimum FS Category A Antenna Discrimination Levels and I_O/N_O Results for M-Star Downlink Interference into an FS Receiving System:

Angle Off Antenna Boresight (degrees)	Minimum Category A Antenna Discrimination Level (dB)	I_O/N_O (dB)	Amount I_O/N_O Exceeds -13 dB (dB)
0 (main beam coupled)	0	24.15	37.15
5 to 10	25	-0.9	12.1
10 to 15	29	-4.9	8.1
15 to 20	33	-8.8	4.2
20 to 30	36	-11.9	1.1
30 to 100	42	-17.9	-4.9
100 to 180	55	-30.9	-17.9

It can be seen from Table 1, that even if the FS path was on a horizontal plane, the FSS downlink interference level exceeds the acceptable level by 1.1 dB. The only apparent way to mitigate against unacceptable main-beam coupling interference levels would be for the FS links to (1) use more EIRP than needed for the fade margin that is necessary for just propagation attenuation purposes or (2) accept a reduced fading margin and the associated poorer than desired grade of service that results[5]. For companies that are providing circuits with minimum 99.999

[5] It should be noted that the paper referenced on page 2 of Ad Hoc MW/40R1, used the words "it tentatively appears" that it "might" be possible for such spectrum sharing to take place as far as acceptable interference from FSS downlinks into FS receivers is concerned. Fixed service systems might be able to overpower the interference received from FSS downlink signals, especially over shorter paths that can result in higher FS link elevation angles.

percent availability in order to provide "wireless fiber" levels of service quality, accepting a lower level of service quality would have an adverse impact on their businesses.

6. Review of Separation Distances

We have reviewed Table B-5 in Motorola's Application, and have recalculated the "no-power" control case for a number of different EIRP levels and using other assumptions more in line with our typical systems. An extract for the 33 dBW case is shown in Table 2 which shows that the separation distances for the "no-power" control case are significantly greater than shown by Ad Hoc MW/40R1. With new systems being designed with 40dBW EIRP, and ultimately moving much closer to the authorized maximum of 55 dBW EIRP being reached, the distances are appropriately increased.

Table 2. Minimum Acceptable Separation Distances Between an FS Transmitting Station and an M-Star Downlink Receiving Station, Assuming That Power Control Is Not Used.

Tx EIRP	Bandwidth	Peak FS TX EIRP Density (dBw/Hz)	Minimum Acceptable FS Transmitter-to-FSS Downlink Receiver Separations (km)				
			FS and FSS System Antenna Orientations				
			FS MB to FSS MB	FS SL to FSS MB	FS SL to FSS SL1 (on-azimuth)	FS MB to FSS SL1 (on-azimuth)	FS MB to FSS SL2 (off-azimuth)
33	5	-34	>100	>100	3.9	98	65
	20	-40	>100	>100	2.05	74	46
	40	-43	>100	>100	1.45	63	37.5

where:

FS MB = 44 dBi
FS SL = 2 dBi
FSS MB = 54.4 dBi
FSS SL1 = -1.6 dBi
FSS SL2 = 10 dBi

Assumptions for the various scenarios and the specific value for each parameter used in Table 2 are given below:

(continued...)

Since that paper, more sensitive FS systems have emerged and even more sensitive ones are being planned than for the "typical" system analyzed in that paper. Besides, both the FS community and Ad Hoc MW/40R1 now appear to be unwilling to accept the levels of interference than what was postulated in this paper.

1. The elevation angle of the FSS downlink station's antenna is assumed to be 22 degrees above the horizontal plane. Situations where the main beam of the FS antenna is pointing in the direction of the FSS downlink receiving station, and the azimuth of the FSS antenna is pointed in the direction of the FS transmitting station, are referred to as FS MainBeam (MB) to FSS Sidelobe on-azimuth (SL1) coupling case. The gain of this antenna in the direction of the FS station's transmitting antenna is assumed to equal 32 - 25log(22 degrees) or -1.6 dBi. The FS link is assumed to be parallel to a horizontal plane containing the FSS station.

2. We also chose a off-azimuth Sidelobe (SL2) level for the FSS antenna of -10 dBi, a level corresponding to the required maximum gain given by Section 25.209 Antenna performance standards, subsection (1)(b) of the Federal Communication Commission's Rules for an angle off boresight ranging from 48 to 180 degrees.

3. FS mainbeam-to-FSS mainbeam, and FS sidelobe-to-FSS mainbeam coupling cases are also possible in certain orientations where one end of a FS link is located on a tall structure and pointing down to a receiver on the ground and the FSS earth station is located on the same line of bearing nearby. In these cases, the FSS mainbeam antenna gain is 54.4 dBi.

4. Similarly, the gain of the assumed 2 ft diameter FS antenna is taken to be equal to 44 dBi. For a SL level we chose the antenna gain that cannot be exceeded for an angle off boresight ranging from 30 to 100 degrees. This maximum gain is given by the 44 dBi on-axis gain minus the minimum required discrimination of 42 dB provided in Section 101.105 Directional Antennas, subsection(c) of the Federal Communication Commission's Rules, table therein for Category A antennas. Thus, the SL level for the FS transmitter was taken to be equal to 2 dBi.

5. With reference to the items listed above concerning terminology, we estimated minimum FS transmitter to FSS downlink receiving station separation distances for FS MB to FSS MB, FS SL to FSS MB, FS MB to FSS SL, and FS SL to FSS SL antenna orientations.

6. We assume, as did Ad Hoc MW/40R1, that the system noise temperature of the M-Star System's downlink receiver is 503 K.

7. Again, as did Ad Hoc MW/40R1, we assume that an acceptable level of interference into the downlink receiver is 13 dB below the receiving system noise, based on an I_O/N_O interference-to-noise power spectral density ratio being equal to -13dB.

8. Bandwidths that come close to covering the range of bandwidths presently used by the FS systems now operating. The 33 dBW level was selected for covering the range generally in use today.

9. Free space transmission losses plus 0.15 dB/km atmospheric loss for "clear air" conditions between the FS transmitter and the FSS downlink receiving station.

7. Sharing Between FSS Uplinks and FS Operations In The 47/50 GHz Band

Ad Hoc MW/40R1 concludes that the required separation distance for an assumed FS protection criteria of -13 dB I_O/N_O is 69.2 km for mainbeam interactions with the emissions of transmitting FSS earth stations in the 47/50 GHz band and that coordination will thus be required. Ad Hoc MW/40R1 also states that a peak EIRP density limit as a function of FS antenna elevation angle will be necessary to protect FSS space station receivers from FS emissions. The requirement to meet EIRP density as a function of FS antenna elevation will impact adversely on a rapid and complete FS deployment.

Motorola's proposed earth station deployment[6] of 2.62 earth stations/km^2 will significantly and materially reduce the available service points for both FS and FSS installations given Motorola's stated separation distance criteria. Furthermore, the Ad Hoc MW/40R1 proposal entails interservice coordination procedures. Such procedures would inhibit FS licensees' ability to deploy rapidly assuming they can deploy at all. These findings are consistent with the results of extensive negotiations regarding the prospect of sharing between ubiquitous FS and FSS systems in the 27.5 - 30.0 GHz band conducted several years ago. Those negotiations failed to yield a viable co-frequency sharing approach and resulted in segmentation of the subject frequency band.

The measures required to protect FS stations from harmful FSS interference would be considerable and likely to defeat the stated deployment objectives of FS and FSS services. Accordingly, the proposed sharing methodology for the 47/50 GHz bank appears unworkable.

8. Recommended Solutions

In document Ad Hoc MW No. 40R1, Motorola has focused its conclusions on the presumption that the FS systems can function successfully by operating at low level and employing ATPC. Those presumptions are fundamentally incorrect. FS is not technically or economically viable using Motorola's presumptions. The application of ATPC, particularly in the area of technological development, economic feasibility and successful operational performance in high quality commercial service, does not appear viable. Ad Hoc MW/40R1 does not address appropriately all technical difficulties. Therefore, Motorola's conclusion is flawed. Unaddressed examples include, but are not limited to, the application of more efficient modulation systems which are expected to be in use within two to three years, the impact on the FSS as advanced FS systems approach the 55 dBW EIRP limit, and the fact that FS systems can operate at higher elevation angles, e.g., up to 45° or more on a routine basis. We also believe that the impact of main beam coupling between the FSS and FS Systems will likely result in harmful interference to FS receivers.

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6 Ad Hoc MW/47.

This document demonstrates that the concept of an EIRP density limit as proposed by Motorola will have a severe adverse impact on high-density FS users. Data is presented that shows that at the level proposed, the resultant path lengths are not sufficiently long to meet current and anticipated requirements.

The existing FS systems in the 38 GHz band and the proposed M-Star network are generally aimed at the same customers and if coordination is required, whenever changes, additions, etc. are needed, we believe that both systems will have severe difficulty in meeting their business commitments in the most efficient and cost-effective manner. The separation distances between the two services can not be as easily defined and adhered to as proposed. We continue to believe that sharing is not reasonably possible and that band segmentation will be required in order to reach a solution allowing satisfactory performance for both the FS and FSS operators in the bands of concern.

With respect to band segmentation, we believe, at a minimum, that FSS operations must be precluded in the 38.6-40.0 GHz band. FSS operations must also be precluded in some expansion bands. In other segments of the band, the possibility of sharing between low-power FS and FSS merit further study. On this basis, we support the band plan for 37.0-40.5 GHz and 47.2-50.2 GHz contained in Ad Hoc MW-7/Rev.-4. Finally, Motorola should have justified the need for use of 6.0 GHz for a worldwide FSS system whose service offers only 99.8% availability.[7]

7 By contrast, FS systems offer a system availability of 99.999%.

APPENDIX C*

*The data sheets enclosed in Appendix C are only representative of current FS systems, and are not inclusive of all systems operating in the 38 GHz band.

CHARACTERISTICS OF REPRESENTATIVE CURRENT FS SYSTEMS*

Data Rate/Capacity	DS-1	DS-3	DS-3
Frequency Range (GHz)	38.6 - 40.0	38.6 - 40.0	38.6 - 40.0
Modulation Type	FSK	4 QAM	OQPSK
Necessary Bandwidth (MHz)	5	50	40
Transmitter Power (dBm)	17	16	15
Transmit e.i.r.p. (dBW)	26 (.33m) 31 (.66m)	25 (.33m) 30 (.66m)	24 (.33m) 29 (.66m)
Receiver Sensitivity (dBm) (Min. BER 1 x 10^{-6})	-88	-71	-80.5
Antenna Size (m)	.33 .66	.33 .66	.33 .66
Antenna Gain (dBi)	39 44	39 44	39 44
Antenna 3 dB Beamwidth (degrees)	1.7 1	1.7 1	1.7 1
Antenna Polarization	H/V	H/V	H/V
Receiver Noise Figure (dB)	11	13	8

* The examples selected for this table are point-to-point FS systems.

CHARACTERISTICS OF EXAMPLE ADVANCED FS SYSTEMS*		
Modulation Type	16 QAM	256 QAM
Frequency Range (GHz)	37.0 - 40.5 GHz	37.0 - 40.5 GHz
Data Rate/Capacity (MB/sec)	90	310
Necessary Bandwidth (MHz)	50	50
Transmitter Power (dBm)	26	26
Transmit e.i.r.p. (dBW)	35 (.33m) 40 (.66m)	35 (.33m) 40 (.66m)
Antenna Size (meters)	.33 .66	.33 .66
Antenna 3 dB Beamwidth	1.7° 1°	1.7° 1°
Antenna Gain (dBi)	39 44	39 44
Receiver Noise Figure (dB)	5	5
Receiver Noise Temperature (°K)	1830	1830
Receiver Sensitivity (dBm) (Min. BER 1×10^{-6})	-72	-60
Antenna Polarization	H/V	H/V

* The examples selected for this table are point-to-point advanced FS systems.

Tel-Link 38 Specifications — T1 Data Rates

General

Operating Frequency Range	38.6 to 40.0 GHz
Capacities and RF Channel Spacing	
1 x 1.544 Mb/s	1T1 - 5 MHz
4 x 1.544 Mb/s	4T1 - 15 MHz
8 x 1.544 Mb/s	8T1 - 15 MHz
16 x 1.544 Mb/s	16T1 - 30 MHz
Compatible Standards	FCC Parts 15, 21 and 94
Transmit/Receive Spacing	700 MHz
Modulation Type	FSK
Tuning Range	350 MHz
Frequency Source	Synthesizer
System Configurations	Non-Protected (1 + 0), Protected (1 + 1)
RF Channel Selection	IDU Controlled or via NMS

Digital Interface

Type	T1 per CCITT G.703
Digital Line Code	AMI or B8ZS
Digital I/O Connectors	100Ω Balanced DB-25

Transmitter

Power Output	+17 dBm (50 mW)
Frequency Stability	±0.001%
Attenuation Range	25 dB

Receiver

Receiver Type	Dual Conversion
Intermediate Frequency	140 MHz
Unfaded BER	10^{-11} or better
Receiver Overload (1 x 10^{-6} BER)	-15 dBm
Receiver Sensitivity (1 x 10^{-6} BER)	
1T1	-88 dBm
4T1	-82 dBm
8T1	-76 dBm
16T1	-73 dBm

Power Supply

Standard Input	-48 VDC
Optional Input	±24 VDC
Power Consumption	
1T1-4T1 Radios	50 Watts
8T1-16T1 Radios	60 Watts

Diagnostics

Loopbacks	Indoor Unit, Outdoor Unit, Local Lines, Remote Lines
Relay Outputs	Five Form "C" Relays

Mechanical

Dimensions	
Indoor Unit	3.5" H x 19" W x 10.5" D
Outdoor Unit	10" diameter x 8" depth
Weights	
Indoor Unit	8.9 lbs.
Outdoor Unit	10 lbs.

Environmental

Temperature Range	
Indoor Unit	-10°C to +50°C
Outdoor Unit	-30°C to +55°C
Relative Humidity	
Indoor Unit	95% at +50°C
Outdoor Unit	100% all weather operation
Altitude	15,000 ft. (4,500 meters)

Service Channels (Optional)

Number of Service Channels	Three
Engineering Orderwire	
Frequency Response	300 - 3400 Hz
Impedance	600Ω balanced
User Interface	RJ-11
Digital Data Channel	
Bit Rate	0 - 9600 b/s
Protocol	RS-232C, RS-422/423
User Interface	DB-9
NMS Data Channel	
Bit Rate	Customized
Protocols	Customized
User Interface	DB-9

IDU to ODU Interconnect

Number of Cables	One
Type	RG-8
Impedance	50Ω unbalanced
Recommended Cable	Belden 9913
Maximum Distance	Up to 1000 ft. (300 meters)
Connector Type	"N" male

Antennas

Diameter	12"	24"
Gain	38 dBi	44 dBi
Beamwidth	1.6°	0.8°
Polarization	Vertical or Horizontal	
Radiation Pattern	High Performance per FCC Category "A"	
Standard Mounting	1.75" to 4.5"	
Windloading		
Operational	112 mph	
Survival	157 mph	

FCC Data

	FCC Identifier	Emission Designator
1T1	KINTL38S-1T	5M00F7W
4T1	KINTL38S-4T	20M0F7W
8T1	KINTL38S-8T	15M0F7W
16T1	KINTL38S-16T	30M0F7W

IDU - Indoor Unit
ODU - Outdoor Unit
NMS - Network Management System

Unless otherwise noted, specifications reflect typical performance of a non-protected terminal connected back-to-back, and are subject to change without notice.

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Tel-Link 38 Specifications — DS-3 Data Rate

General

Operating Frequency Range	38.6 to 40.0 GHz
Capacities	1 x 44.736 Mb/s + 1 x 1.544 Mb/s wayside channel (optional)
Compatible Standards	FCC Parts 15, 21 and 94
Transmit/Receive Spacing	700 MHz
Modulation Type	4-FSK
Tuning Range	350 MHz
Frequency Source	Synthesizer
System Configurations	Non-Protected (1 + 0), Protected (1 + 1)
RF Channel Selection	IDU Controlled or via NMS

Digital Interface

Type	T3 & T1 per CCITT G.703
Digital Line Code	
1T3	B3ZS
1T1	AMI or B8ZS selectable
Digital I/O Connectors	
1T3	75Ω unbalanced BNC
1T1	100Ω balanced DB-15

Transmitter

Power Output	+17 dBm (50 mW)
Frequency Stability	±0.001%
Attenuation Range	25 dB

Receiver

Receiver Type	Dual Conversion
Intermediate Frequency	140 MHz
Unfaded BER	10^{-11} or better
Receiver Overload (1 x 10^{-6} BER)	-20 dBm
Receiver Sensitivity (1 x 10^{-6} BER)	-69 dBm

System Gain

1 x 10^{-6} BER	86 dB

Power Supply

Standard Input	-48 VDC
Optional Input	±24 VDC
Power Consumption	50 Watts

Diagnostics

Loopbacks	Indoor Unit, Outdoor Unit, Local Line, Remote Line
Relay Outputs	Five Form "C" Relays

Mechanical

Dimensions	
Indoor Unit	1.75" H x 19" W x 10.5" D
Outdoor Unit	10" diameter x 8" depth
Weights	
Indoor Unit	7 lbs.
Outdoor Unit	10 lbs.

Environmental

Temperature Range	
Indoor Unit	-10°C to +50°C
Outdoor Unit	-30°C to +55°C
Relative Humidity	
Indoor Unit	95% at +50°C
Outdoor Unit	100% all weather operation
Altitude	15,000 ft. (4,500 meters)

Service Channels (Optional)

Number of Service Channels	Three
Engineering Orderwire	
Frequency Response	300 - 3400 Hz
Impedance	600Ω balanced
User Interface	RJ-11
Digital Data Channel	
Bit Rate	0 - 9600 b/s
Protocol	RS-232C, RS-422/423
User Interface	DB-9
NMS Data Channel	
Bit Rate	Customized
Protocols	Customized
User Interface	DB-9

IDU to ODU Interconnect

Number of Cables	One
Type	RG-8
Impedance	50Ω unbalanced
Recommended Cable	Belden 9913
Maximum Distance	Up to 1000 ft. (300 meters)
Connector Type	"N" male

Antennas

Diameter	12"	24"
Gain	38 dBi	44 dBi
Beamwidth	1.6°	0.8°
Polarization	Vertical or Horizontal	
Radiation Pattern	High Performance per FCC Category "A"	
Standard Mounting	1.75" to 4.5"	
Windloading		
Operational	112 mph	
Survival	157 mph	

FCC Data

FCC Identifier	KINTL38S-45
Emission Designator	40M0F7W
FCC Rules	Part 15, 21 and 94
Frequency Range	38.6 to 40.0 GHz
Frequency Tolerance	±0.001%

IDU - Indoor Unit
ODU - Outdoor Unit
NMS - Network Management System

Unless otherwise noted, specifications reflect typical performance of a non-protected terminal connected back-to-back, and are subject to change without notice.

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HARRIS

MicroStar® Millimeter Wave Radio

38 GHz North American digital hierarchy

System Characteristics

Frequency Range: 37,000 - 38,400 MHz   38,600 - 40,000 MHz

Bit Rate Capacity: 4 DS1, 8 DS1

Channel Spacing: 4 DS1 (7.5 MHz) 8 DS1 (15 MHz)

Xmtr/Rcvr Frequency Spacing: 700 MHz

Modulation: (4-FSK) 4-level Frequency Shift Keying

Frequency Source: Synthesizer

Tuning Range: 200 MHz

Line Code: B8ZS or AMI

Data Channel: 19.2 kbaud asynchronous data

Data Interface: RS232 or RS423

Configurations: Non-protected.
Future provision for 1+1 equipment protection

IDU/ODU Interconnection: Separation 1000 ft. max..
Single coaxial cable, Belden 9913 (RG-8) or equivalent.

NMS Interface: SNMP, FarScan™, StarScan™
and dry relay contacts

Craft Interface: Laptop using MicroStar CIT

Fault Detection: Auto-Diagnostics, replace-me LEDs
Alarms: Indoor Unit, Outdoor Unit, Cable, Sum

Operating Environment:	**Indoor**	**Outdoor**
Guaranteed Performance;	0°C to +50°C	-30°C to +55°C
Operational;	-10°C to +55°C	-40°C to +55°C
Humidity;	95% max *(non-condensing)*	100 %

Power Sources; 21 to 60 Vdc, positive or negative ground

Power Consumption: < 30 watts

System Gain

System Gain dB:

BER	4 DS1	8 DS1
-10^{-3}	102.5	100.0
-10^{-4}	100.5	98.0

Transmitter Characteristics

Power Output: +16 dBm minimum *(at antenna port)*

RF Power Attenuation: 30 dB

Power Mute Control: > 50 dB attenuation

Frequency Stability: 10 ppm including aging

T/I Ratio (Copolar): < +20 dB Co-channel
Adjacent Channel < 0 dB   Two channels away < -25 dB

Receiver Characteristics

Noise Figure: 8 dB at antenna port

Sensitivity (dBm):

BER	4 DS1	8 DS1
-10^{-3}	-86.5	-84.0
-10^{-4}	-84.5	-82.0

Residual BER: $< 10^{-1?}$ BER

RF Overload: - 10 dBm no errors

Frequency Stability: 10 ppm including aging

FEC: Built-in

Regulatory Information

Frequency Plans: FCC Parts 15, 21, 94, and 101

FCC Identifiers:
4 DS1 (BCK8LIUST3804T1-1)   8 DS1 (BCK8LIUST3808T1-1)

FCC Type Acceptance: Granted June 7, 1996

Digital Interface: Conforms to ITU-T Rec. G.703, Bellcore TR-TSY-000499 and Trans Canada Guideline TG-23.007

Electromagnetic Interference Standards:
U.S. Federal Communications Commission Part 15

Mechanical Characteristics

Cable Connector: Indoor to Outdoor; Type "N-Type Female

Rack Size: 483 mm (19") EIA or ETSI relay rack, wall mounted or cabinets.

Dimensions: Outdoor; 10.7" dia. 5.25" deep
Indoor; 1 RMS (1.75" high) x (19" wide) x (10.5" deep)

Weight: Outdoor; 22 lbs. *including antenna*   Indoor; 8 lbs.

Antenna Characteristics

Type: 1 ft. and 2 ft. Class A
High Performance integrated parabolic antenna

Gain: 1 ft. (39 dBi)   2 ft. (44 dBi)

Mounting: Pole mount on a 2" or 4" diameter pole

Alignment: Azimuth & Elevation. Detachable mechanism
Azimuth; Coarse ± 180°   Fine ± 5°
Elevation; Coarse ± 25°   Fine ± 5°

Polarization: Horizontal or Vertical

Windload: Operational (90 mph)   Survival (125 mph)

Performance specifications given here are typical and apply to transmitters/receivers connected back-to-back and must be confirmed before they become applicable to any specific system, contract or order.

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HARRIS

MicroStar® *Plus* Millimeter Wave Radio

38 GHz North American digital hierarchy

System Characteristics

Frequency Range: 37,000 - 38,400 MHz 38,600 - 40,000 MHz

Bit Rate Capacity: DS3

Channel Bandwidth: 40 MHz

Xmtr/Rcvr Frequency Spacing: 700 MHz

Modulation: OQPSK

Frequency Source: Synthesizer - full tuning range

Diplexer Bandwidth: 350 MHz

Digital Interface: 75 ohms, unbal.

Line Code. B3ZS

IDU/ODU Interconnection: Separation 1000 ft. max.
Single coaxial cable, Belden 9913 (RG-8) or equivalent

Data Channel: 19.2 kbaud asynchronous data

Data Interface: RS232 (V24) or RS423 (V10)

Configurations: Non-protected, 1+1 equipment protection

NMS Interface: SNMP, FarScan™, StarScan™
and dry relay contacts

Craft Interface: Laptop using MicroStar CIT

Fault Detection: Auto-Diagnostics, replace-me LEDs
Alarms: Indoor Unit, Outdoor Unit, Cable, Sum

Operating Environment:	**Indoor**	**Outdoor**
Guaranteed Performance;	0°C to +50°C	-30°C to +55°C
Operational;	-10°C to +55°C	-40°C to +55°C
Humidity;	95% max *(non-condensing)*	100 %

Power Sources: 21 to 60 Vdc, positive or negative ground

Power Consumption: < 45 watts
Consumption could be less depending on the capacity.

Transmitter Characteristics

Power Output: +15 dBm at antenna port

RF Power Attenuation: 40 dB in 1 dB steps

Power Mute Control: > 50 dB attenuation

Frequency Stability: 5 ppm including aging

System Gain

System Gain: BER 1×10^{-3} 97 dB BER 1×10^{-6} 95.5 dB

Receiver Characteristics

Noise Figure: 8 dB maximum at antenna port

Sensitivity: BER 1×10^{-3} -82 dBm BER 1×10^{-6} -80.5 dBm

Residual BER: $< 10^{-12}$ BER

RF Overload: *(no errors)* - 20 dBm

Frequency Stability: 5 ppm including aging

FEC: Built-in

Regulatory Information

Frequency Plans: FCC Parts 15, 21, 94, and 101

Electromagnetic Interference Standards:
U.S. Federal Communications Commission Part 15

Mechanical Characteristics

Cable Connector: Indoor to Outdoor; Type "N-Type Female

Rack Size: Indoor Unit; 483 mm, 19" EIA or ETSI relay rack
Outdoor Unit: Pole, Wall or Windows mount.

Dimensions: Including antenna for ODU
ODU; 320 mm high x 320 mm wide x 106 mm deep
12.6" high x 12.6" wide x 4" deep
IDU; 1 RMS 45 mm high x 483 mm wide x 267 mm deep
1 RMS 1.75" high x 19" wide x 10.5" deep

Weight: Outdoor; 4.9 kg, 10.8 lbs. *including antenna*
Indoor; 3.5 kg, 8 lbs.

Antenna Characteristics

Type: Continuous Transverse Stub (CTS)
Flat antenna per FCC 21.108, Category A

Gain: 38 dBi Optional 44 dBi
Mounting: Pole, wall or windows mount.
Alignment: TBD
Polarization: Horizontal or Vertical
Windload: Operational; 150 Km/h, 90 mph
Survival: 205 Km/h, 125 mph

Typical performance specifications given here apply to transmitters and receivers connected back-to-back and must be confirmed before they become applicable to any specific system, contract or order.

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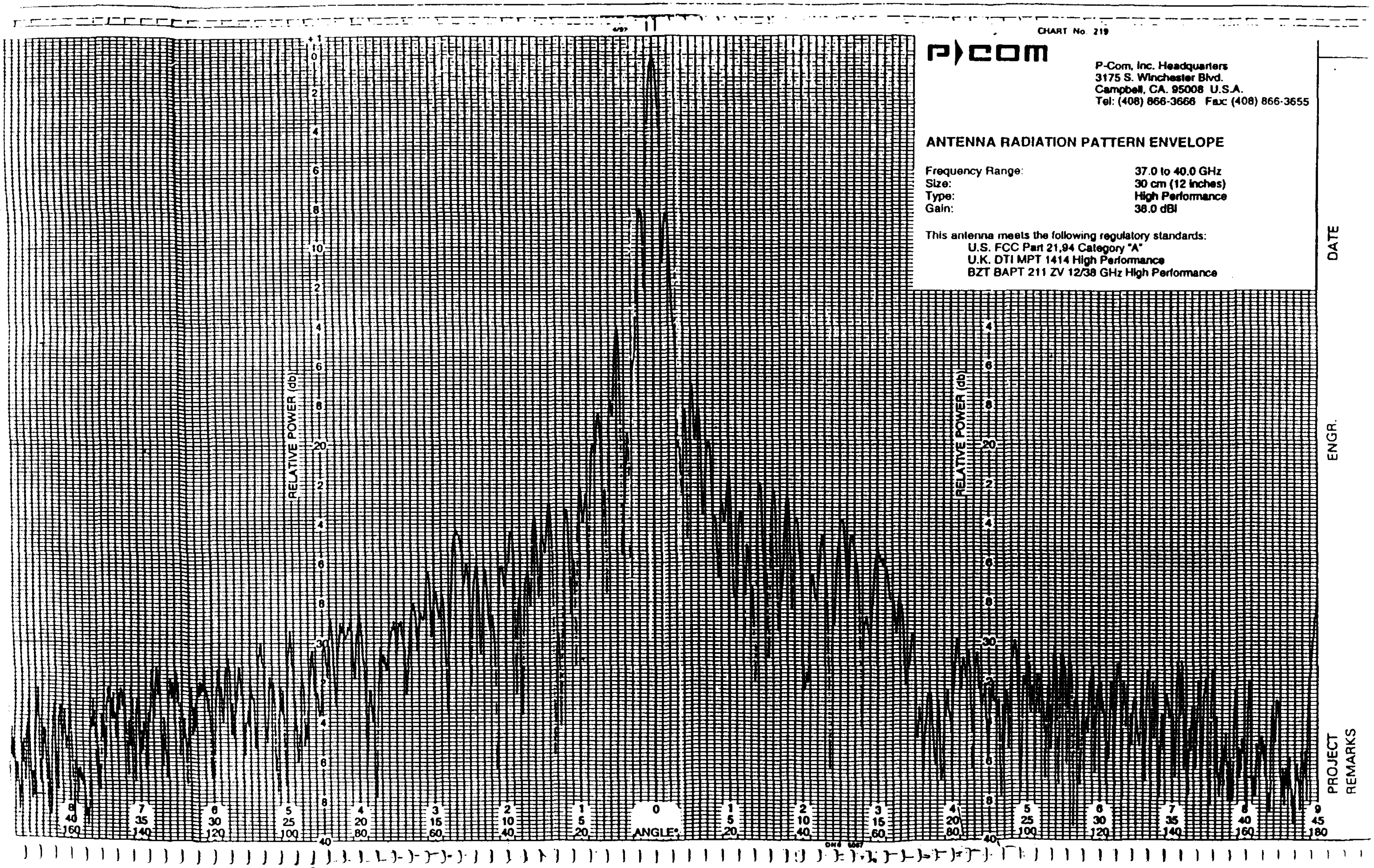

CHART No. 219
P)COM
P-Com, Inc. Headquarters
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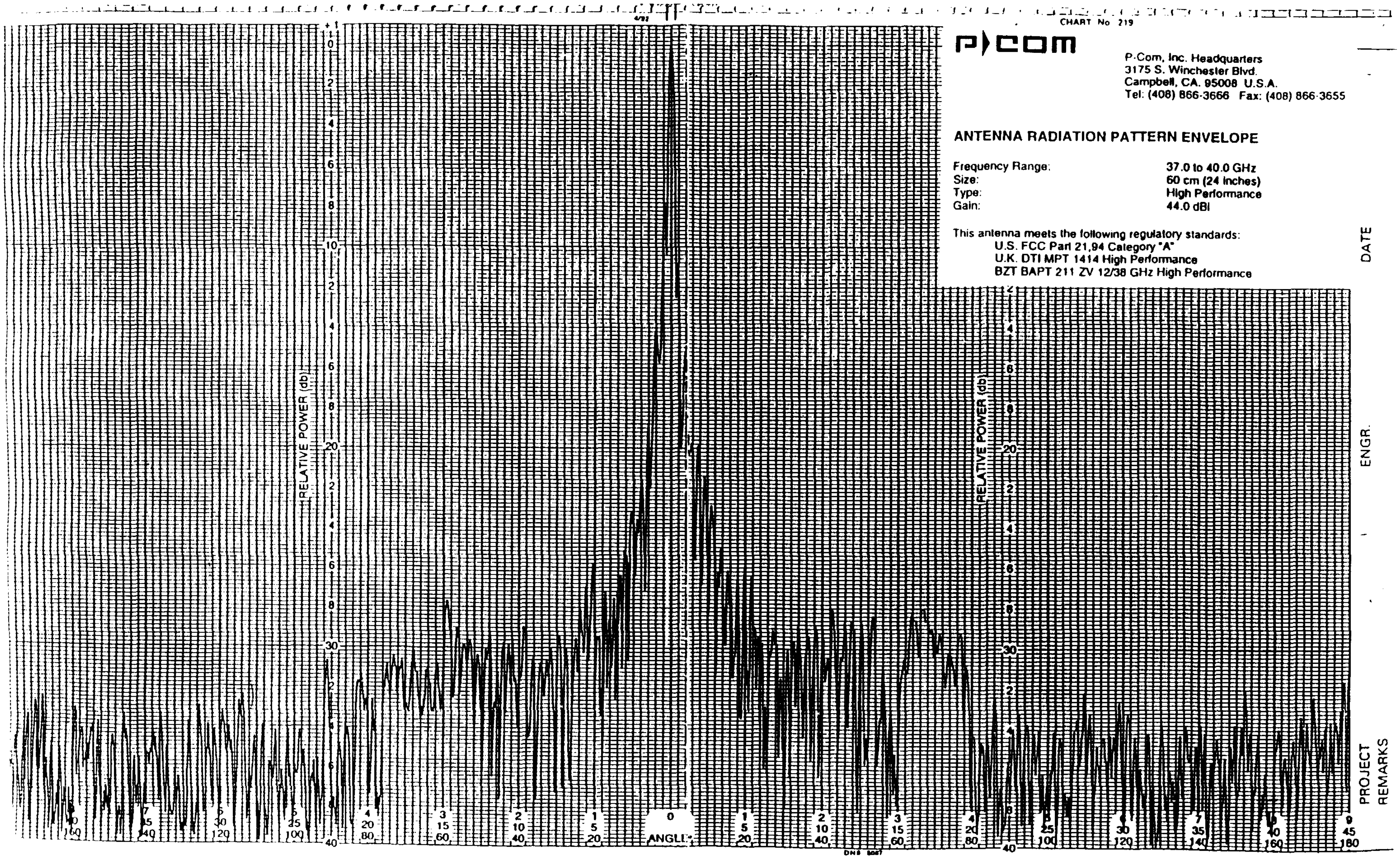
Tel: (408) 866-3666 Fax: (408) 866-3655
ANTENNA RADIATION PATTERN ENVELOPE
Frequency Range: 37.0 to 40.0 GHz
Size: 30 cm (12 inches)
Type: High Performance
Gain: 38.0 dBi
This antenna meets the following regulatory standards:
U.S. FCC Part 21,94 Category "A"
U.K. DTI MPT 1414 High Performance
BZT BAPT 211 ZV 12/38 GHz High Performance
RELATIVE POWER (db)
RELATIVE POWER (db)
ANGLE°
DATE
ENGR.
PROJECT
REMARKS



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ANTENNA RADIATION PATTERN ENVELOPE

Frequency Range:	37.0 to 40.0 GHz
Size:	60 cm (24 inches)
Type:	High Performance
Gain:	44.0 dBi

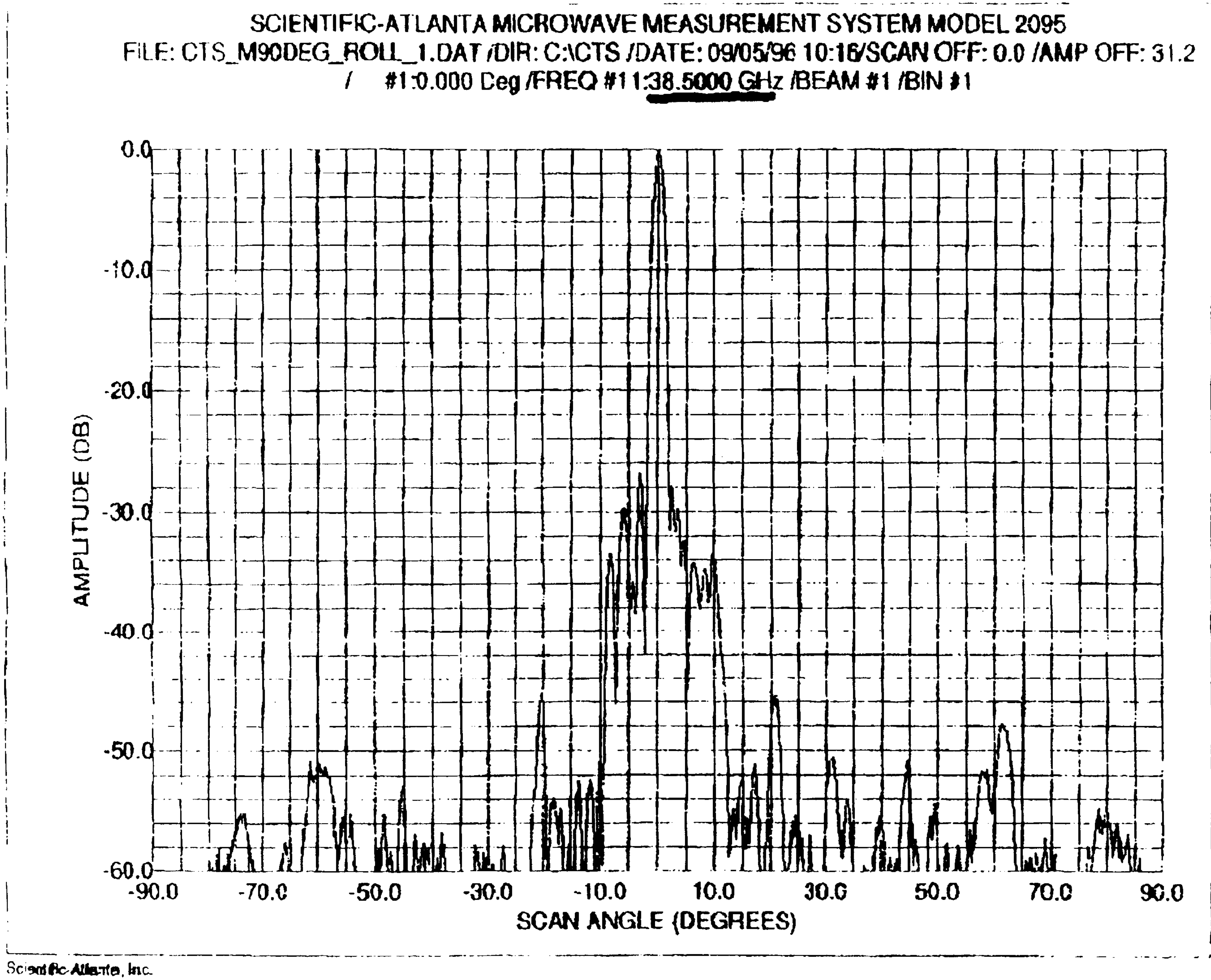
This antenna meets the following regulatory standards:

- U.S. FCC Part 21,94 Category "A"
- U.K. DTI MPT 1414 High Performance
- BZT BAPT 211 ZV 12/38 GHz High Performance

DATE

ENGR.

PROJECT
REMARKS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/ #1:0.000 Deg /FREQ #11:38.5000 GHz /BEAM #1 /BIN #1
AMPLITUDE (DB)
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-90.0
-70.0
-50.0
-30.0
-10.0
10.0
30.0
50.0
70.0
90.0
SCAN ANGLE (DEGREES)
Scientific-Atlanta, Inc.

9/6/96